



## INTERACTIONS IN SOCIAL SCIENCE

The interaction term received intense scrutiny, much of it critical, upon its introduction to social science. Althauser (1971) wrote, “It would appear, in short, that including multiplicative terms in regression models is not an appropriate way of assessing the presence of interaction among our independent variables” (466). Zedeck (1971) concurred, “The utility of the moderator variable research is limited by statistical problems, by the limited understanding of the statistical operation of moderators, and by lack of a rapid systematic approach to the identification of moderators” (307).

As Friedrich (1982) noted, early criticism of interactions focused on three concerns: difficulty in interpreting coefficients, colinearity among independent variables induced by the multiplication of terms, and the nature of measurement of independent variables (whether they be interval, ratio, or nominal scales). These concerns inspired some scholars (e.g., Althauser 1971; Zedeck 1971) to object to any usage of interactive terms. Others suggested alternative methods to incorporate interactions in models by rescaling variables to reduce colinearity (Allison 1977; Cronbach 1987; Dunlap and Kemery 1987; Smith and Sasaki 1979; Tate 1984).

Two and a half decades after the seminal article by Friedrich (1982) defending interactions, full and accurate understanding of the modeling, interpretation, and presentation of interactive hypotheses still eludes social scientists, even though multiplicative terms appear frequently in empirical analysis. For example, in a count of journal articles that appeared from

1996 to 2001 in the three top political-science journals,<sup>1</sup> we have found that 54 percent of articles use some statistical methods (defined as articles reporting any standard errors or hypothesis tests). Of these articles, 24 percent employ interactive terms. This amounts to about one-eighth of all articles published during this time.<sup>2</sup> Despite this appreciable and increasing use of interaction terms in empirical analysis, careful consideration of important classes of theoretical arguments in political science strongly suggests that they nonetheless remain considerably underutilized. Further, when interactions are employed in empirical work, several misunderstandings regarding their interpretation still permeate the field.

This widespread and perhaps expanding usage of interactions notwithstanding, we contend that still more empirical work should contain interactions than currently does, given the substance of many political-science arguments. Indeed, interactive arguments arise commonly in every empirical subfield in the social sciences. For political scientists, for example, interactive arguments appeal to scholars who study political institutions, to scholars who study political behavior, and perhaps especially to those who study the impact of institutions on political behavior, not to mention political economy, political culture, and all the other substantive areas of study within political science. These interactive arguments arise commonly in other disciplines: sociologists interested in the interactions between individuals and their social contexts, microeconomists examining the effect of public policies such as the minimum wage on different types of workers, macroeconomists studying the impact of fiscal or monetary policy under varying institutional conditions, and psychologists seeking to identify heterogeneity in individuals' reactions to experimental treatments. Interactions enable testing of these conditional-effect propositions.

In political science, for example, the core of most institutional arguments, reflecting perhaps the dominant approach to modern, *positive*<sup>3</sup> political science, implies interactive effects. In one influential statement of the approach, Hall (1986) states:

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1. *American Political Science Review*, *American Journal of Political Science*, and *Journal of Politics*.

2. Incidentally, these shares likely dramatically understate the mathematical and technical nature of the field since our denominator includes pure-theory articles, formal and philosophical, and our numerator excludes formal theory. The share of statistical and formal-theoretical articles in these journals likely approaches 75 percent of all non-political-philosophy articles.

3. We use the term *positive* as opposed to *normative* here and do not intend it to connote *formal* necessarily.

the institutional analysis of politics . . . emphasizes institutional relationships, both formal and conventional, that bind the components of the state together and structure its relations with society . . . [I]nstitutions . . . refers to the formal rules, compliance procedures, and standard operating practices that structure the relationship between individuals in various units of the polity and economy . . . Institutional factors play two fundamental roles . . . [They] affect the degree of power that any one set of actors has over policy outcomes [. . . and they . . .] influence an actor's definition of his own interests, by establishing his . . . responsibilities and relationship to other actors . . . *With an institutionalist model we can see policy as more than the sum of countervailing pressure from social groups. That pressure is mediated by an organizational [i.e., institutional] dynamic.* (19; emphasis added)

Thus, in this approach, and inherently in all institutional approaches, institutions are *interactive* variables that funnel, moderate, or otherwise shape the political processes that translate the societal structure of interests into effective political pressures, those pressures into public-policy-making responses, and/or those policies into outcomes. Across all the methodological and substantive domains of institutional analysis, further examples abound:

[political struggles] *are mediated* by the institutional setting in which they take place. (Ikenberry 1988, 222–23; emphasis added)

[1] institutions *constrain* and *refract* politics but . . . are never the sole “cause” of outcomes. Institutional analyses do not deny the broad political forces that animate [. . . class or pluralist conflict, but stress how . . .] institutions *structure* these battles and, in so doing, influence their outcomes. [2. They] focus on how [the effects of] macrostructures such as class are *magnified* or *mitigated* by intermediate-level institutions . . . [they] help us integrate an understanding of general patterns of political history with an explanation of the *contingent* nature of political and economic development . . . [3] Institutions may be resistant to change, but *their impact on political outcomes can change* over time in subtle ways in response to shifts in the broader socioeconomic or political *context*. (Steinmo and Thelen 1992, 3, 11–12, 18; emphasis added)

the idea of structure-induced equilibrium is clearly a move [toward] incorporating institutional features into rational-choice approaches. Structure and procedure *combine* with preferences to produce outcomes. (Shepsle 1989, 137; emphasis added)

Other recent examples include research that connects the societal structure of interests to effective political pressure through electoral institutions: most broadly, plurality-majority versus proportional representation (e.g., Cox 1997; Lijphart 1994; Ordeshook and Shvetsova 1994); research that studies how governmental institutions, especially those that affect the number and polarization of key policymakers (veto actors), shape policy-making responses to such pressures (e.g., Tsebelis 2002); research that stresses how the institutional configuration of the economy, such as the coordination of wage-price bargaining, shapes the effect of certain policies, such as monetary policy (see Franzese, 2003b, for a review). Examples could easily proliferate yet further.

In every case, and at each step of the analysis, from interest structure to outcomes (and back), the role of institutions is to *shape, structure, or condition*<sup>4</sup> the effect of some other variable(s)<sup>5</sup> on the dependent variable of interest. That is, most (probably all) institutional arguments are inherently interactive. Yet, with relatively rare exceptions, empirical evaluations of institutional arguments have neglected this interactivity in their models.

A more generic example further illustrates the common failure of empirical models to reflect the interactions that theoretical models imply. Political scientists and economists consider principal-agent (i.e., delegation) situations interesting, problematic, and worthy of study because, if each had full control, agents would determine policy,  $y_1$ , by responding to some (set of) factor(s),  $X$ , according to some function,  $y_1 = f(X)$ . Principals, however, would respond to some different (set of) factor(s),  $Z$ , according to some function,  $y_2 = g(Z)$ . For example, the principal might be a current government, which responds to various political-economic conditions in setting inflation policy, and the agent an unresponsive central bank, as in Franzese (1999). Scholars then offer some arguments about how institu-

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4. Extending the list of synonyms might prove a useful means of identifying interactive arguments. When one says *x alters, changes, modifies, magnifies, augments, increases, intensifies, inflates, moderates, dampens, diminishes, reduces, deflates*, and so on, some effect (of  $z$ ) on  $y$ , one has offered an interactive argument.

5. Institutions seem most often to condition the impact of structural variables: for example, interest, demographic, economic, party-system structure, and so on. We suspect that this reflects some as-yet unstated general principle of institutional analysis.

tional and other environmental conditions determine the monitoring, enforcement, and other costs,  $C$ , principals must incur to force agents to enact  $g(\mathbf{Z})$  instead of  $f(\mathbf{X})$ . In such situations, the connection between the realized policy,  $y$ , and the agent's preferred policy function,  $y_1$ , will depend on  $C$  or some function of  $C$ , say,  $k(C)$ . Similarly, the effect of the principal's policy function,  $y_2$ , on the realized policy will depend on  $C$  or some function of  $C$ , say,  $[1 - k(C)]$ . This reasoning suggests that the realized policy should be modeled as  $y = k(C) \times f(\mathbf{X}) + [1 - k(C)] \times g(\mathbf{Z})$  with  $0 \leq k(C) \leq 1$  and  $k(C)$  weakly increasing (see, e.g., Lohmann 1992, on the banks, governments, and inflation example). Thus, the effect on  $y$  of each  $c \in C$  generally depends on  $\mathbf{X}$  and  $\mathbf{Z}$ , and the effect of each  $x \in \mathbf{X}$  and of each  $z \in \mathbf{Z}$  generally depends on  $C$ . That is, all factors that contribute to monitoring and enforcement costs modify the effect on  $y$  of all factors to which the principals and agents would respond differently, and, vice versa, the effect of all factors that determine monitoring and enforcement costs depends on all factors to which principals and agents would respond differently.<sup>6</sup> Most empirical models of principal-agent situations do not reflect this inherent interactivity.

For those who study individual or mass political behavior, opportunities to specify interactive hypotheses also abound. Scholars who argue that the effects of some set of individual characteristics (e.g., partisanship, core values, or ideology) depend on another set of individual characteristics (e.g., race, ethnicity, or gender) are proposing hypotheses that can and should be analyzed with interactive terms. Research questions that ask how the impact of some experimental treatment or environmental context (e.g., campaign or media communications) depends on the level of some individual characteristic (e.g., political awareness) likewise imply interactive hypotheses. Questions that explore how context (e.g., minority neighborhood composition or news media coverage of an issue) conditions the effect of some other predictor (e.g., racism) also reflect interactive hypotheses. Generally speaking, research questions that propose heterogeneity in how different types of individuals (or different microlevel units, even more generally) respond to their environments and institutional (i.e., macrolevel) contexts can and should be modeled interactively.<sup>7</sup>

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6. Franzese (1999, 2002) shows how to use nonlinear regression to mitigate the estimation demands of such highly interactive propositions.

7. These last will also often imply *spatial interdependence*; see the following for methodological issues implied: Franzese and Hays (2005), Beck, Gleditsch, and Beardsley (2006), and contributions to *Political Analysis* 10(3). For multilevel contextual models, see the section "Random-Effects Models and Hierarchical Models" in Chapter 5, and the contributions to *Political Analysis* 13(4).

Interaction terms are widely used in statistical research in social science, and, in many more cases, theories suggest that interactions should be used although they are not. Despite their proliferation, some confusion persists regarding how to interpret these terms. Accordingly, we now provide practical advice to assist students and scholars to minimize this confusion.